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MISSOURI - KANSAS CITY BASIN

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WINDY KNOLL LAKE DAM

WARREN COUNTY, MISSOURI

MO 30512

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

**United States Army
Corps of Engineers**
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St. Louis District

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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SEPTEMBER 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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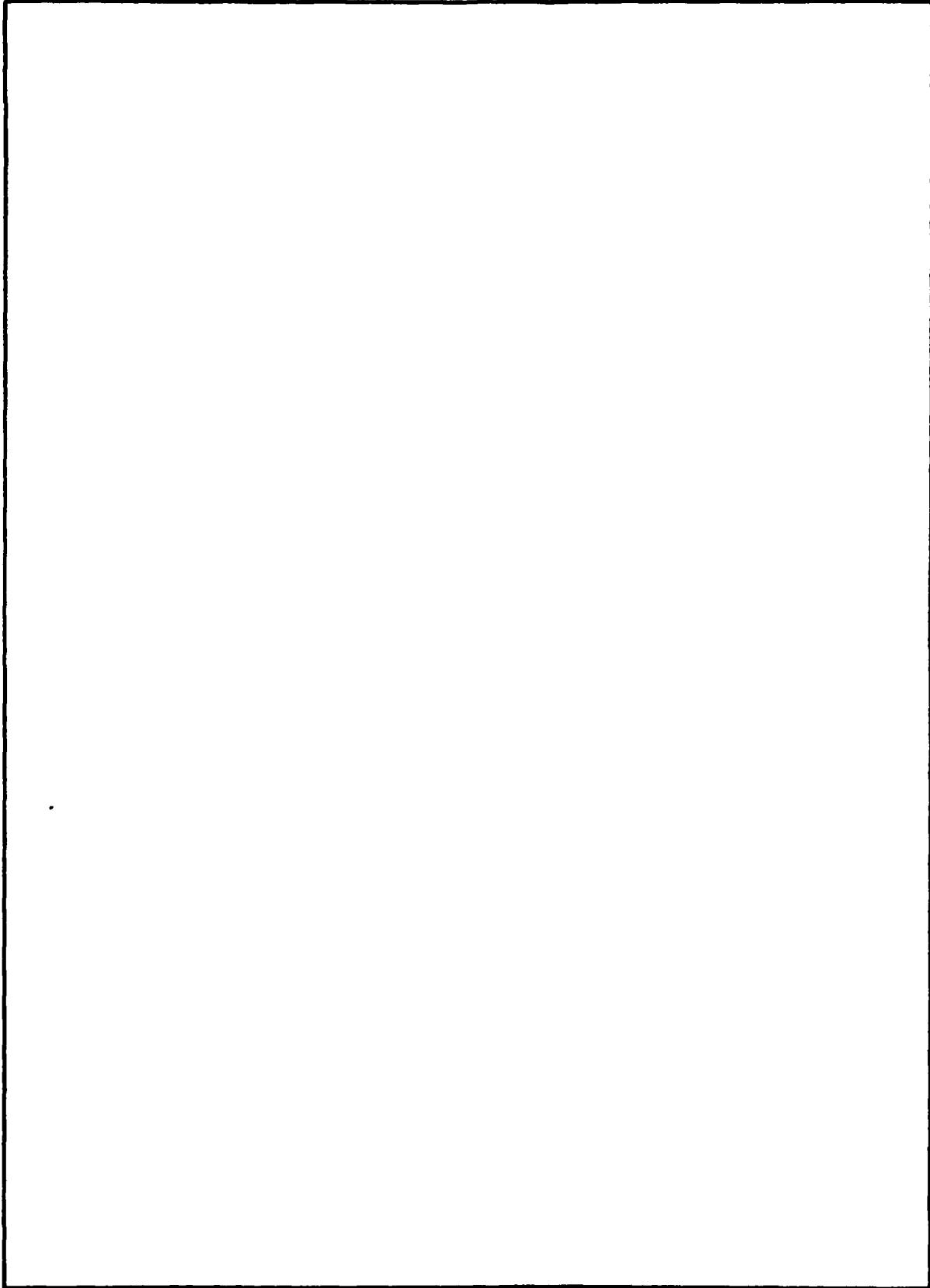
MISSOURI - KANSAS CITY BASIN

WINDY KNOLL LAKE DAM
WARREN COUNTY, MISSOURI
MO 30512

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT. CORPS OF ENGINEERS
210 TUCKER BOULEVARD. NORTH
ST. LOUIS. MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Windy Knoll Lake Dam, MO 30512, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Windy Knoll Lake Dam, MO 30512.   It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: _____**SIGNED**_____   **25 SEP 1980**

                    Chief, Engineering Division   Date

APPROVED BY: _____SIGNED_____   25 SEP 1980

                    Colonel, CE, District Engineer   Date

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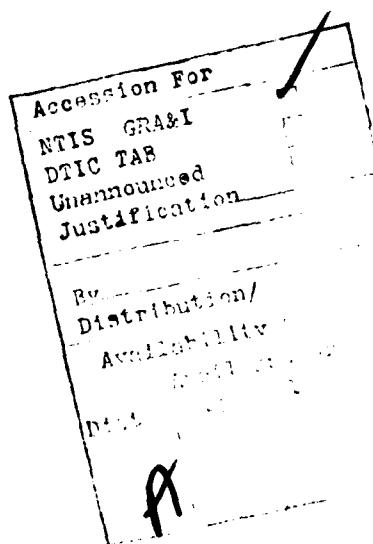
WINDY KNOLL LAKE DAM

MISSOURI INVENTORY NO. 30512

WARREN COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

SEPTEMBER 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam: Windy Knoll Lake Dam

State Located: Missouri

County Located: Warren

Stream: Subtributary of Charrette Creek

Date of Inspection: 9 June 1980

The Windy Knoll Lake Dam was visually inspected by engineering personnel
of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The
purpose of this inspection was to assess the general condition of the dam with
respect to safety and, based upon this inspection and available data,
determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the
results of certain hydrologic/hydraulic investigations performed under the
direction of the inspection team. Based on the visual inspection and the
results of the hydrologic/hydraulic investigations, the present general
condition of the dam is considered to be somewhat less than satisfactory. The
following deficiencies were noticed during the inspection and are considered
to have an adverse effect on the overall safety and future operation of the
dam:

1.   Numerous trees up to 4 inches in size exist on the downstream face of
     the dam. Patches of brushy undergrowth were also found on the
     downstream slope near the toe of the dam at the original stream
     location. Tree roots can provide passageways for lake seepage which

could lead to a piping condition (progressive internal erosion) resulting in failure of the dam. Brush may conceal animal burrows which could also provide passageways for lake seepage.

2. Erosion of the grass covered upstream face of the dam apparently by wave action and/or fluctuations of the lake surface level has created a near vertical bank up to about 12 inches high at the normal waterline. A grass covered slope is not considered adequate protection to prevent erosion by wave action or fluctuations of the lake level.

3. Surface cracks that appear to be due to drying of the soil, some as wide as 1 inch, as deep as 10 inches, and 4 feet in length, exist throughout most of the crest of the dam and particularly in areas where the turf cover is marginal. Surface cracking can promote erosion of the dam.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Windy Knoll Lake Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the fact that a series of manmade lakes; Lake Sheffborg, Lake Lucern, and Lake Innsbrook, lie within the possible flood damage zone for this dam, and since failure of this dam by overtopping could result in successive failure of the three downstream dams which would endanger the lives of a number of people with dwellings about these lakes as well as those persons living within the downstream flood damage zone, it is recommended that the spillway for this dam be designed for the PMF. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillway is capable of passing lake outflow corresponding to about 55 percent

of the PMF lake inflow and the lake outflow resulting from the 1 percent chance (100-year frequency) flood. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be two miles. Accordingly, within the possible damage zone are portions of the Innsbrook Subdivision development including three dams and several dwellings along the shore of the lake upstream of Dam No. 31442. These dams (Nos. 31442, 30519 and 11243), according to the Corps of Engineers, have a high hazard classification.

A review of available data did not disclose that seepage or stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies and safety defects reported herein.
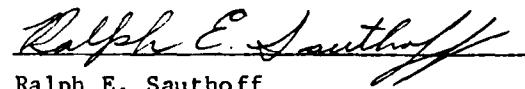
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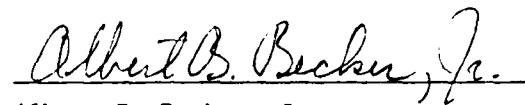
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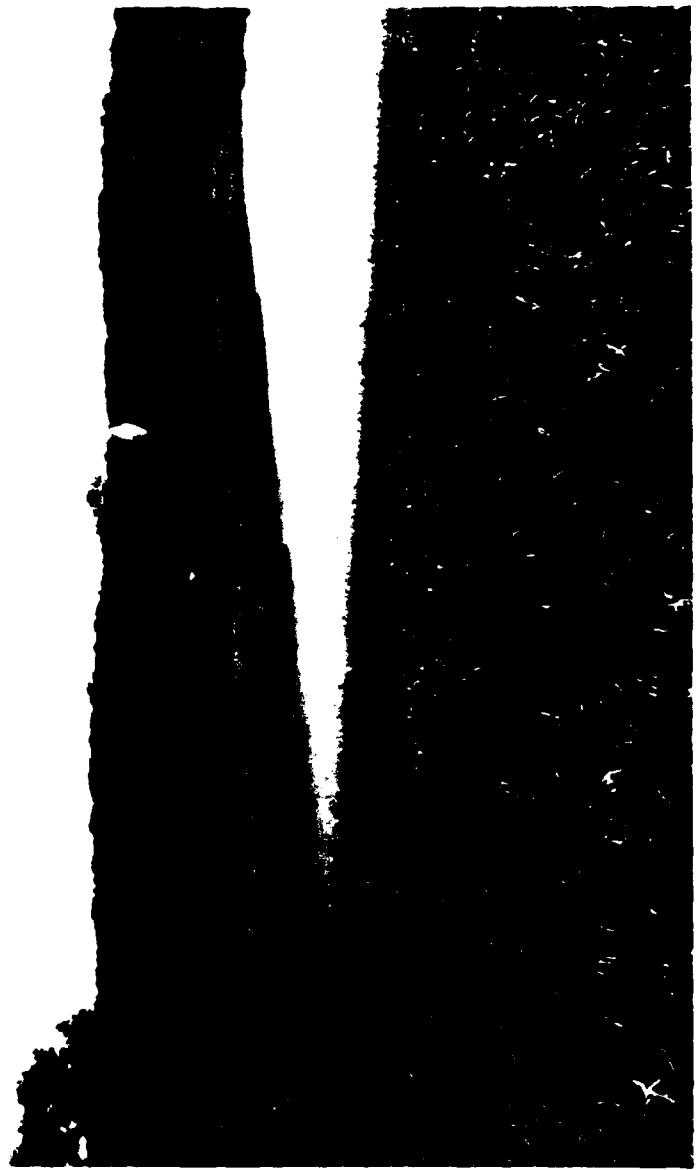
OVERVIEW WINDY KNOLL LAKE DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

WINDY KNOLL LAKE DAM - MO 30512

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

WINDY KNOLL LAKE DAM - MO 30512

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

    a.   Authority. The National Dam Inspection Act, Public Law 92-367, dated
8 August 1972, authorized the Secretary of the Army, through the Corps of
Engineers, to initiate a program of safety inspection of dams throughout the
United States. Pursuant to the above, the St. Louis District, Corps of
Engineers, directed that a safety inspection of the Windy Knoll Lake Dam be
made.

    b.   Purpose of Inspection. The purpose of this visual inspection was to
make an assessment of the general condition of the dam with respect to safety
and, based upon available data and this inspection, determine if the dam poses
a hazard to human life or property.

    c.   Evaluation Criteria. This evaluation was performed in accordance
with the "Phase I" investigation procedures as prescribed in "Recommended
Guidelines for Safety Inspection of Dams", Appendix D to "Report to the Chief
of Engineers on the National Program of Inspection of Non-Federal Dams", dated
May 1975.

1.2 DESCRIPTION OF PROJECT

    a.   Description of Dam and Appurtenances. The Windy Knoll Lake Dam is an
earthfill type embankment rising approximately 35 feet above the natural
streambed at the downstream toe of the barrier. The embankment has an
upstream slope of approximately 1v on 3.7h, a crest width of about 12 feet,

and a downstream slope on the order of 1v on 3.1h. At the location of the original stream channel and at an elevation approximately 20 feet below the dam crest, the downstream slope flattens to about 1v on 5.2h. The length of the dam is approximately 462 feet. A plan and profile of the dam are shown on Plate 3 and a cross-section of the dam is shown on Plate 4. At normal pool elevation the reservoir impounded by the dam occupies approximately 7 acres. There is no drain line to dewater the lake.

The spillway, an excavated earth section, is located at the left, or east, abutment. The spillway outlet channel, an excavated earthen trapezoidal section, is cut into the hillside of the abutment. An earth bank constructed on the right side serves to confine flow to the channel. The channel extends approximately 75 feet from the centerline of the dam where it joins the natural drainage course of the adjacent watershed. This tributary meets the original stream on which the dam is constructed at a point about 125 feet downstream of the dam. Stone riprap up to about 6 inches in size covers most of the spillway outlet channel invert through the improved section. A cross-section of the spillway is shown on Plate 4.

b. **Location.** The dam is located on an unnamed subtributary of Charrette Creek, about 1 mile south and just west of the intersection of Muenz Road and State Highway M, and approximately 4 miles southwest of Wright City, Missouri, as shown on the Regional Vicinity Map, Plate 1. The dam is located in the southwest quadrant of Section 32, Township 47 North, Range 1 West, within Warren County.

c. **Size Classification.** The size classification based on the height of the dam and storage capacity, is categorized as small (per Table 1, Recommended Guidelines for Safety Inspection of Dams).

d. **Hazard Classification.** The Windy Knoll Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by

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the St. Louis District, extends two miles downstream of the dam. Within the possible flood damage zone are portions of the Innsbrook Subdivision development including three dams and several dwellings along the shore of the lake upstream of Dam No. 31442. These dams (Nos. 31442, 30519 and 11243), according to the Corps of Engineers, have a high hazard classification. Those features lying within the downstream damage zone reported by the Corps of Engineers, St. Louis District, were verified by the inspection team.

e.   Ownership. The lake and dam are owned by the Willmarjim Company, a Missouri Corporation. The President of the company is Mr. William F. Sheff. Mr. Sheff's address is 5757 Manchester Avenue, St. Louis, Missouri 63110.

f.   Purpose of Dam. The dam impounds water for recreational use.

g.   Design and Construction History. According to the Owner, the dam was designed and constructed in about 1969 by Russell Bolinger, a local contractor and builder of earthen dams. Mr. Bolinger is deceased. The Owner reported that prior to construction of the dam, the proposed site was investigated by a representative of the Missouri Geological Survey and that test borings were obtained at the site of the proposed dam. However, records of these investigations, the test borings, and the design of the dam by Mr. Bolinger were unavailable.

h.   Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of an excavated earth type spillway.

1.3 PERTINENT DATA

a.   Drainage Area. The area tributary to the lake is essentially meadowland. The watershed above the dam amounts to approximately 48 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 11 cfs* (W.S.Elev. 770.4)

(2) Spillway capacity ... 263 cfs.

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on the elevation of the lake, assumed to be the normal pool level, as shown on the 1972 Wright City, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 769.8

(2) Normal pool ... 770.0

(3) Spillway crest ... 770.0

(4) Maximum experienced pool ... 770.4*

(5) Top of dam ... 772.4 (min.)

(6) Streambed at centerline of dam ... 742+ (est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 770.0) ... 900 ft.

(2) Length at maximum pool (Elev. 772.4) ... 1,000 ft.

e. Storage.

(1) Normal pool ... 63 ac. ft.

(2) Top of dam (incremental) ... 17 ac. ft.

f. Reservoir Surface

(1) Normal pool ... 7 acres

(2) Top of dam (incremental) ... 1 acre

*Based on an estimate of depth of flow at spillway as observed by the Owner.

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier, to the top of the dam.

    (1) Type ... Earthfill, homogeneous*
    (2) Length ... 462 ft.
    (3) Height ... 35 ft.
    (4) Top width ... 12 ft.
    (5) Side slopes
         a. Upstream ... 1v on 3.7h (above waterline)
         b. Downstream ... 1v on 3.1h to 1v on 5.2h
    (6) Cutoff ... Core trench*
    (7) Slope protection
         a. Upstream ... Grass
         b. Downstream ... Grass

h. Spillway.

    (1) Type ... Uncontrolled, excavated earth
    (2) Location ... Left abutment
    (3) Crest ... Elevation 770.0
    (4) Approach channel ... Lake
    (5) Outlet channel ... Excavated earth, trapezoidal section

i. Emergency Spillway ... None

j. Lake Drawdown Facility ... None

*Per Owner

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2.1 DESIGN

Data relating to the design of the dam was unavailable.

2.2 CONSTRUCTION

As previously stated, the dam was constructed about 1969 by Russell Bolinger, a local contractor and builder of dams. According to the Owner, a core trench for seepage cutoff was excavated along the axis of the dam and that seams of shale were encountered during excavation of the trench. The Owner reported that the material used to backfill the trench and construct the dam was clay that was selected from areas to be occupied by the lake. The Owner also recalled that the embankment material was compacted using a sheepsfoot roller. No records of the construction of the dam were available.

2.3 OPERATION

The lake level is uncontrolled and governed by the elevation of the crest of an excavated earth type spillway. No indication was found that the dam has been overtopped. The Owner reported that the dam has never been overtopped and that the highest lake level experienced to date produced a depth of flow at the spillway estimated to be about 5 inches.

2.4 EVALUATION

a. _Availability_. Engineering data for assessing the design of the dam and spillway were unavailable.

b. _Adequacy_. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

3.1 FINDINGS

a.   General. A visual inspection of the Windy Knoll Lake Dam was made by
Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and
A. B. Becker, Jr., Civil and Soils Engineer, on 9 June 1980. An examination
of the dam area was also made by an engineering geologist, Jerry D. Higgins,
Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing
the site geology. Also examined at the time of the inspection, were the areas
and features below the dam within the potential flood damage zone.
Photographs of the dam taken at the time of the inspection are included on
Pages A-1 through A-3 of Appendix A. The locations of the photographs taken
during the inspection are indicated on Plate 3.

b.   Site Geology. The dam site is located near the southern edge of the
Dissected Till Plains Section of the Central Lowlands Physiographic Province
and the northern edge of the Ozark Plateaus Physiographic Province. The
topography is gently rolling with only 60 to 70 feet of relief between the
reservoir and the surrounding drainage divides. No bedrock outcrops were
noted at the site; however, nearby borings indicate over 100 feet of loess and
glacial drift underlain by Ordovician-age sedimentary rock of the Kimmswick
formation. The bedrock is gently dipping to the north, and no faults were
observed or reported at the site.

The Kimmswick formation is a light gray, coarsely crystalline,
medium-bedded to massive limestone. Weathered exposures characteristically
appear pitted. The limestones are susceptible to solution weathering and may
have solution-enlarged joints and bedding planes, sinkholes, etc. Often the
karst features are filled with Pennsylvanian-age rubble.

The unconsolidated surficial materials consist of thick deposits of loess
overlying glacial drift. The dam and reservoir are located on soils of the
Keswick series. These soils are deep, moderately well-drained materials
formed from loessal deposits. They are dark grayish brown silts near the

surface and become more clayey with depth. According to the Unified Soil
Classification System, the soils are classified CL or CL-ML materials, are low
in permeability, and are susceptible to erosion. The silty soils of the
Hatton series cap the ridges above the reservoir. These soils formed from
loess deposits and exhibit engineering properties similar to the Keswick
soils. Glacial till overlain with loess was noted in the stream channel
immediately downstream from the dam. The till consisted primarily of blocky
clay with chert gravel and large glacial erratics.

There appear to be no significant geotechnical problems at the dam site.
No adverse geologic conditions were observed that would be considered to
severely affect the performance of the dam or reservoir.

c. Dam. The visible portions of the upstream and downstream faces of
the dam (see Photos 1 and 2) as well as the dam crest, were inspected and
except for surface cracks in the dam crest and some minor erosion of the
upstream face at the waterline, appeared to be in sound condition. No
settlement of the crest, sloughing of the slopes, or misalignment of the dam
were noted. The surface cracks in the dam crest were random in direction and
were found throughout the entire length of the dam. Cracks up to 1 inch in
width (see Photo 5), 10 inches in depth, and about 4 feet in length were
observed. Erosion, apparently by wave action, had created a near vertical
bank up to 12 inches high at the normal waterline. No animal burrows were
found in the face of the dam, but it did appear that several burrows had
existed at some prior time.

Trees up to about 4 inches in diameter were found on the downstream
face of the dam (see Photos 2 and 6), and at the downstream toe of the dam in
the vicinity of the original stream channel, the undergrowth was quite dense.
No seepage was noticed; however, due to the presence of dense undergrowth at
the toe of the dam, not all areas could be thoroughly examined. Except for
the dam crest which had been recently mowed, the grass on the dam was about 30
inches high at the time of the inspection. Examination of a soil sample
obtained from the dam surface indicated the material to be a yellow-brown,
silty lean clay (CL) of low-to-medium plasticity.

The excavated earth spillway (see Photos 3 and 4), except for some erosion of the invert at the junction of the spillway and the downstream channel, appeared to be in satisfactory condition. The invert of the spillway channel was protected from erosion by stone riprap up to about 6 inches in size. The eroded area of the channel was about 3 feet deep and up to 6 feet wide.

d.   Downstream Channel.   At a point approximately 700 feet downstream of the dam, the downstream channel, an unimproved section, joins Lake Scheffborg.   Lake Scheffborg is the first of three manmade, tandem oriented, lakes located on the tributary just downstream of the dam.   The other two lakes in succession are Lake Lucern and Lake Innsbrook.   The dam for Lake Scheffborg which has a surface area of about 10 acres, lies approximately 0.35 miles downstream of the Windy Knoll Dam;   the dam for Lake Lucern, a lake with a surface area of about 42 acres, lies about 1.0 mile downstream;   and the dam for Lake Innsbrook, a lake with a surface area of almost 55 acres, lies approximately 1.6 miles downstream.   The stream tributary joins Charrette Creek at a point about 1.0 mile downstream of the Lake Innsbrook Dam.

e.   Reservoir.   At the time of the inspection, the reservoir was near normal level and clear.   No erosion of the lake banks was evident.   For the most part, the area about the lake is meadowland.   The amount of sediment within the lake could not be determined during the inspection;   however, due to the vegetation covering the surrounding area, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection and noted herein, are not considered of significant importance to warrant immediate remedial action, but should be rectified in the near future.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

According to the Owner, the dam receives periodic routine maintenance such as mowing of the grass on the dam crest, yearly removal by trapping of muskrats, and additions of riprap to the invert of the spillway channel.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam, and there is no reservoir regulation plan.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

It is recommended that maintenance of the dam also include removal of trees and periodic cutting of grass on the slopes. Measures should also be taken to prevent further erosion of the upstream face at the normal waterline. It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a.   Design Data. Design data are not available.

b.   Experience Data. The drainage area and lake surface area were
determined from the 1972 USGS Wright City, Missouri, Quadrangle Map. The
proportions and dimensions of the spillway and dam were developed from surveys
made during the inspection. Records of rainfall, streamflow, or flood data
for the watershed were not available.

According to the St. Louis District, Corps of Engineers, the
estimated flood damage zone, should failure of the dam occur, extends 2 miles
downstream of the dam. The dams for Lake Scheffborg, Lake Lucern, and Lake
Innsbrook, all of which are classifed as high hazard by the Corps of
Engineers, lie within the flood damage zone.

c.   Visual Observations.

(1) The spillway, a shallow, broad-crested, excavated earth,
trapezoidal section, is located at the left abutment.

(2) Spillway releases within the capacity of the spillway outlet
should not endanger the dam.

(3) The original stream channel abuts the toe of the dam.

d.   Overtopping Potential. The spillway is inadequate to pass the
probable maximum flood, without overtopping the dam. The spillway is
adequate, however, to pass one-half the probable maximum flood without
overtopping the dam. The results of the dam overtopping analyses are as
follows:

(Note: The data appearing in the following table were extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Dam (Elev. 772.4)	Duration of Overtopping of Dam (Hours)
0.50	238	772.3	0.0	0.0
1.00	620	773.6	1.2	0.9

Elevation 772.4 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be approximately 263 cfs, which is the routed outflow corresponding to about 55 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 1.2 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a silty lean clay of low-to-medium plasticity) to that used to construct this dam has shown evidence that under certain conditions such as high velocity flow, the material can be very erodible. Such a condition exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of flow over the dam crest, a maximum of 1.2 feet, and the duration of flow over the dam, 0.9 hours, are considerable, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable; however, there is a possibility that they could result in failure by erosion of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow passing the spillway and dam crest are presented on pages B-1 and B-2 of the

Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 100-year frequency flood are shown on pages B-3 through B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10 and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-10.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. <u>Visual Observations</u>. Visual observations of conditions which
adversely affect the structural stability of the dam are discussed in Section
3, paragraph 3.1c.

b. <u>Design and Construction Data</u>. No design or construction data
relating to the structural stability of the dam are known to exist. Seepage
and stability analyses comparable to the requirements of the "Recommended
Guidelines for Safety Inspection of Dams" were not available, which is
considered a deficiency. These seepage and stability analyses should be
performed for appropriate loading conditions (including earthquake loads) and
made a matter of record.

c. <u>Operating Records</u>. No appurtenant structures or facilities requiring
operation exist at this dam. According to the Owner, no records are kept of
the lake level, spillway discharge, dam settlement, or seepage.

d. <u>Post Construction Changes</u>. According to the Owner, no post
construction changes have been made or have occurred which would affect the
structural stability of the dam.

e. <u>Seismic Stability</u>. The dam is located in an area close to the
boundary separating the Zone I and Zone II seismic probability areas. An
earthquake of the magnitude that might occur in this area would not be
expected to cause structural damage to a well constructed earth dam of this
size provided that static stability conditions are satisfactory and
conventional safety margins exist. However, it is recommended that the
prescribed seismic loading be applied in any stability analyses performed for
this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a.   Safety. A hydraulic analysis indicated that the spillway is capable of passing lake outflow of about 263 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicates that for storm runoff of probable maximum flood magnitude, the lake outflow would be about 620 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 82 cfs.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the inspection that could adversely affect the safety of the dam. These items include trees and brush on the downstream slope of the embankment, surface cracks in the dam crest, and the lack of adequate slope protection to prevent erosion of the upstream face of the dam.

b.   Adequacy of Information. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessments of the hydrology of the watershed and capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c.   Urgency. The remedial measures recommended in paragraph 7.2 for the items concerning the safety of the dam noted in paragraph 7.1a should be accomplished within the near future.

7-1

d.   Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e.   Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a.   Recommendations. The following actions are recommended.

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased in order to pass lake outflow resulting from a storm of probable maximum flood magnitude. In either case, the spillway should be protected to prevent erosion.

(2) Obtain the necessary soil data and perform dam seepage and stablity analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b.   Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Remove the trees and brushy type undergrowth that may conceal animal burrows from the downstream face of the dam. Tree roots and animal burrows can provide passageways for lake seepage that could lead to a piping condition and failure of the dam. The areas at the toe of the dam should be examined for animal burrows, sloughing, and other defects once they are cleared of undergrowth, etc.

(2) Provide some form of protection other than grass for the upstream face of the dam at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by a fluctuating lake level.

(3) The areas of the dam crest that have only a marginal cover of grass should be provided with some type of durable plant cover to prevent cracking of the surface. Surface cracks can promote erosion of the dam.

(4) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure features of being in satisfactory operational condition.

(5) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.

LINCOLN COUNTY

ST. CHARLES COUNTY

WARRENTON
POP 2057

TRUESDALE
POP 262

WRIGHT CITY
POP 945

MUENZ RD.

WINDY KNOLL LAKE

REIFSNIDER STATE FOREST

ASPENHOFF

WARREN COUNTY
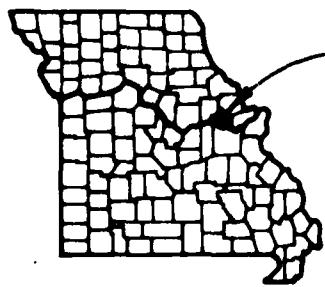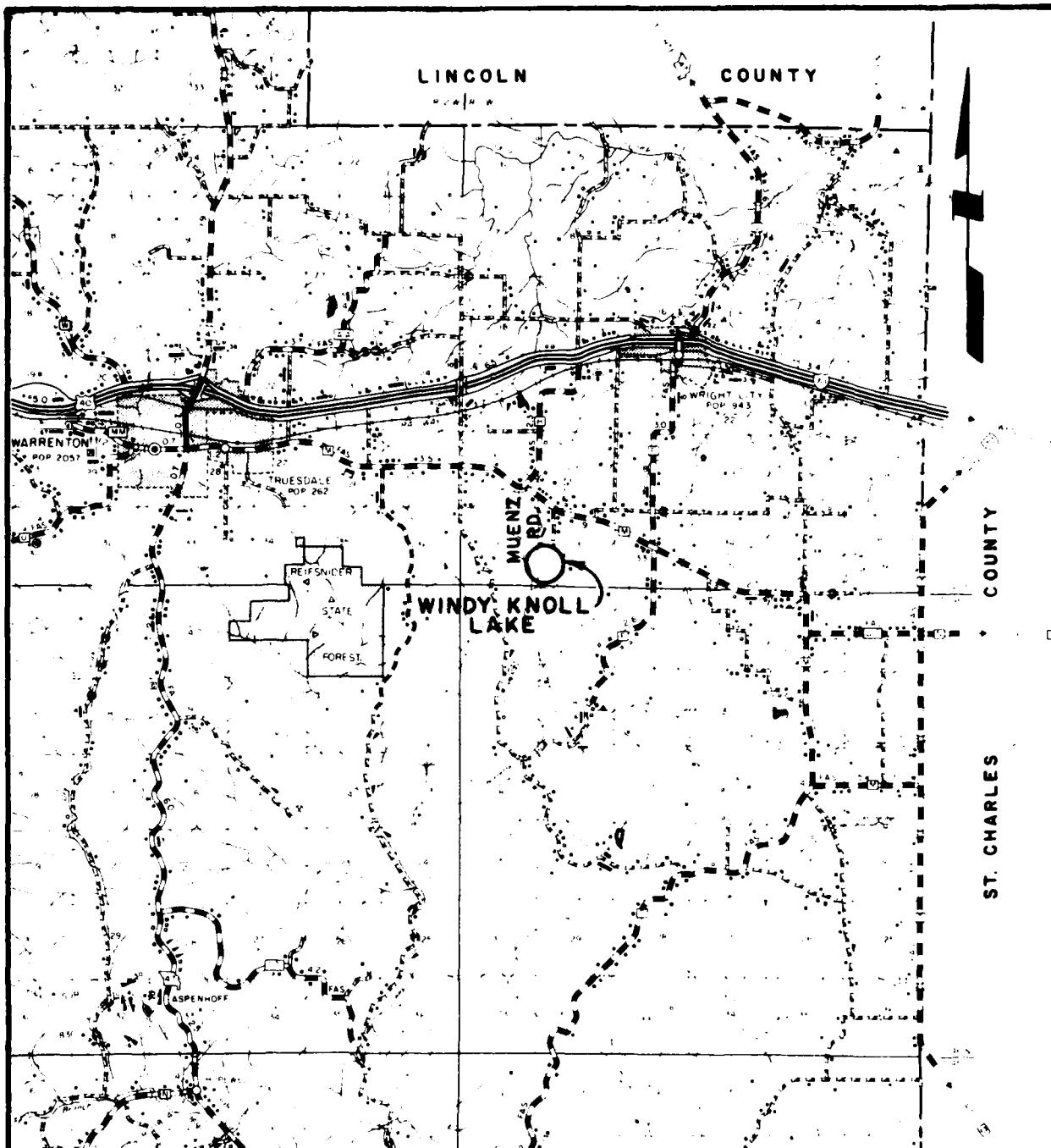
LOCATION MAP

WINDY KNOLL LAKE DAM

SCALE (MILES)
0   1   2   3   4

REGIONAL VICINITY MAP

PLATE I

WATERSHED BOUNDARY

WINDY KNOLL LAKE

SPILLWAY
CHANNEL

DAM

DAM NO. 31482

MUENZ ROAD

STRACK · CHURCH
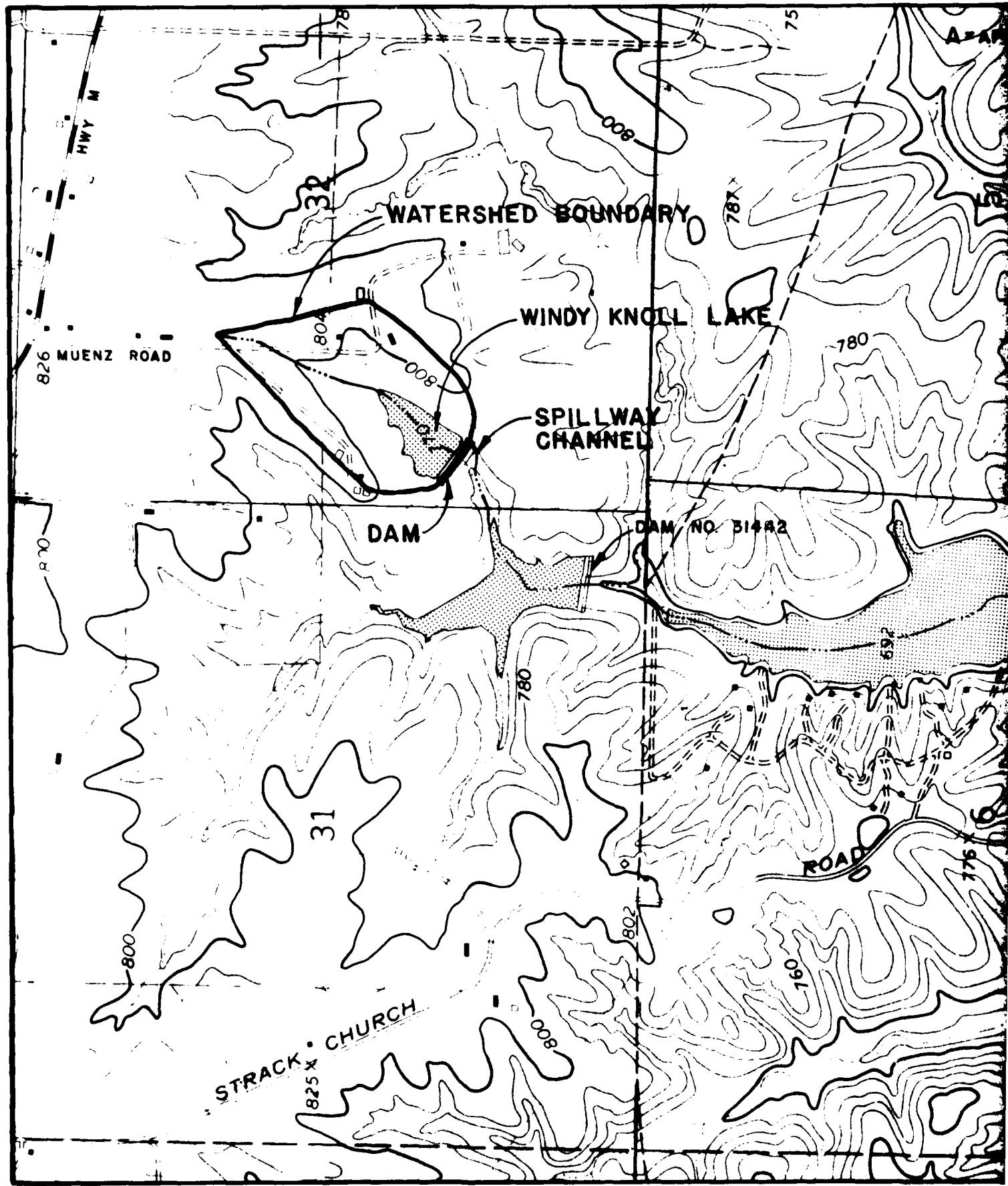
A=APPROXIMATE LIMIT OF DOWNSTREAM DAMAGE ZONE

722

780
×783

× A

DAM NO. 11243

700

692

DAM NO. 30519

× 769

749

Harmonie Ch

176×9

ROAD

700

WINDY KNOLL LAKE DAM

0   1000   2000   3000

SCALE IN FEET
(CONTOUR INTERVAL 20 FEET)

LAKE WATERSHED MAP

PLATE 2

TRIBUTARY

ORIGINA

STONE RIPRAP

OUTLET
CHANNEL

②

④

⑤

①

SPILLWAY

③
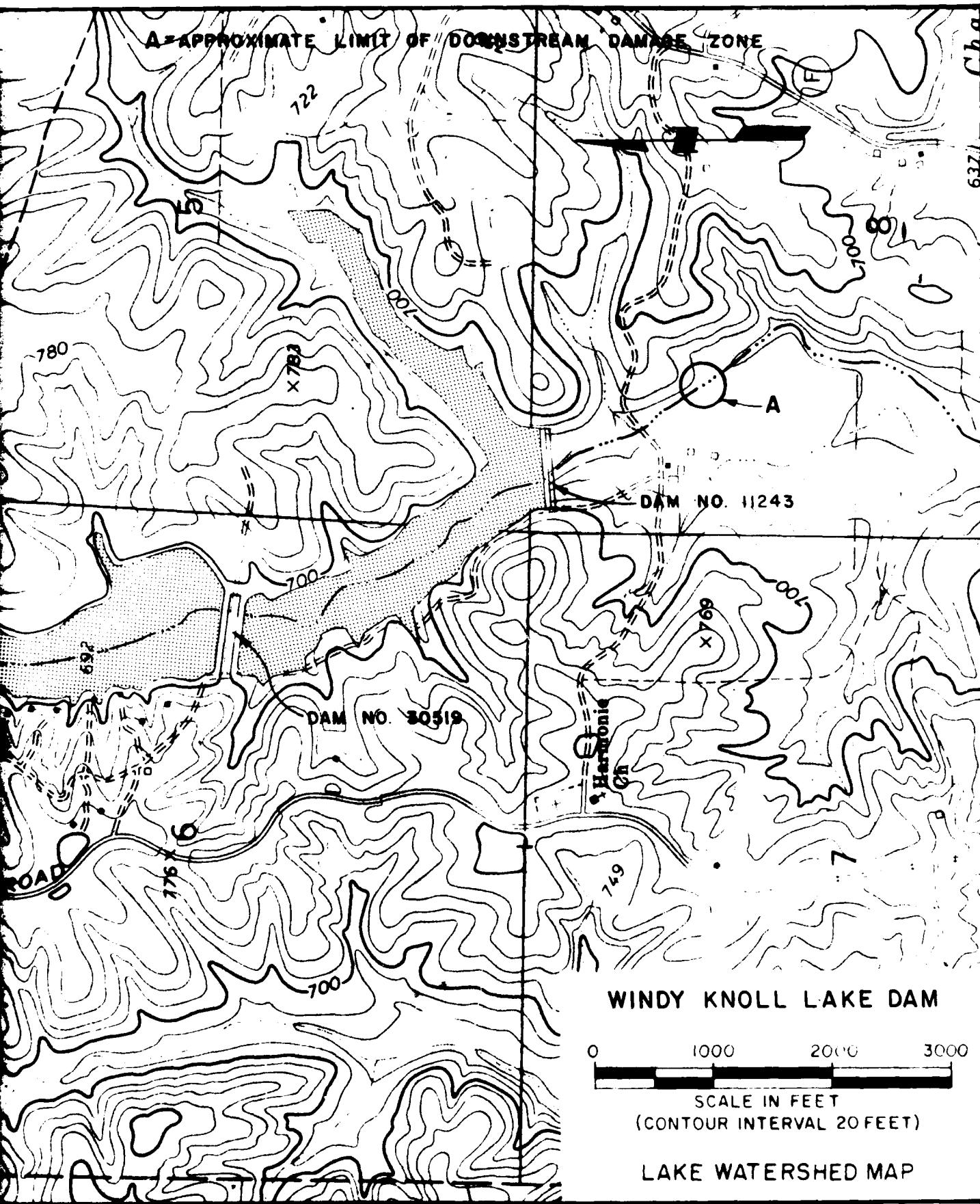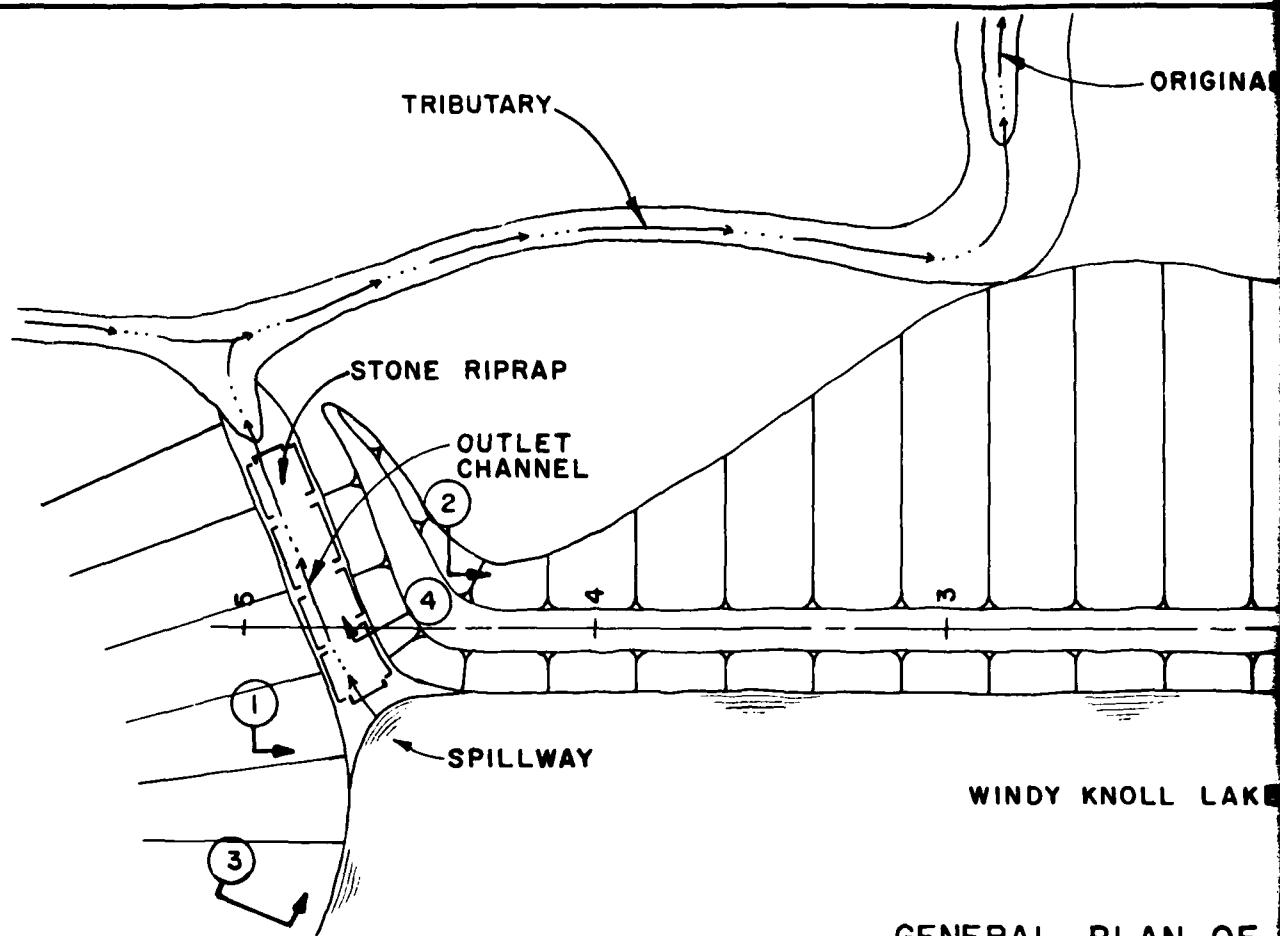
WINDY KNOLL LAKE

GENERAL PLAN OF
SCALE: 1"=50'

ABUTMENT
STA. 4+62

LOW POINT STA. 4+50
EL. 772.4

SPILLWAY CREST
EL. 770.0

780

770

760

ELEV. (FT. ABOVE M.S.L.)

5

4

3

⑥
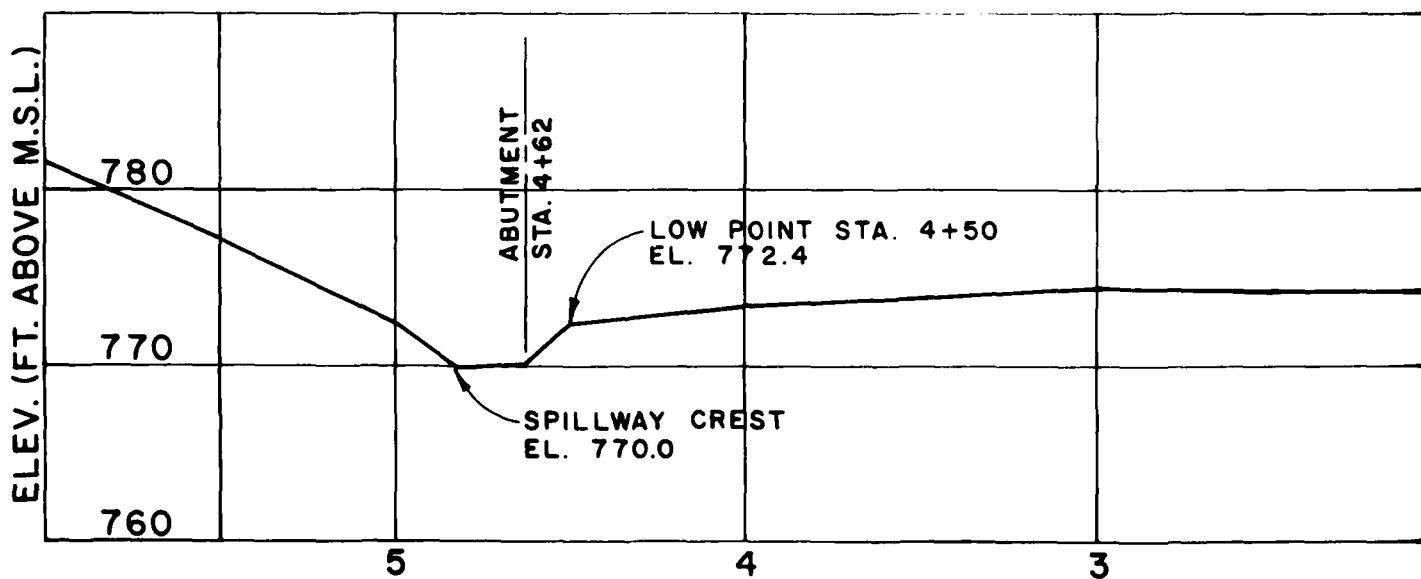
PHOTO LOCATION & KEY
(SEE APPENDIX A)

PROFILE DAM CRE
SCALES: 1"=10'V., 1"=50'

ORIGINAL STREAM

TOE OF SLOPE

⑥

⑤

─

○

₵ DAM

DY KNOLL LAKE

AL PLAN OF DAM
SCALE: 1"=50'

TOP OF DAM

ABUTMENT
STA. 0+00

2   1   0   -1

FILE DAM CREST
LES: 1"=10'V., 1"=50'H.

, 2

PLATE 3

WATER SURFACE
EL. 769.8
(6-9-80)

ℂ DAM

IV:3.7H

TOP OF DAM
EL. 774.4

IV:3.1H

EL. 753.7

IV

780

770

760

750

740

ELEV. (FT. ABOVE M.S.L.)

40   0   40   80

CROSS-SECTION STA.
SCALES: 1"=10' V., 1"=20

SPILLWAY CREST=
NORMAL POOL
EL. 770.0

ℂ DAM

ℂ INVERT

770

760

ELEV. (FT. ABOVE M.S.L.)

40   0   40   80
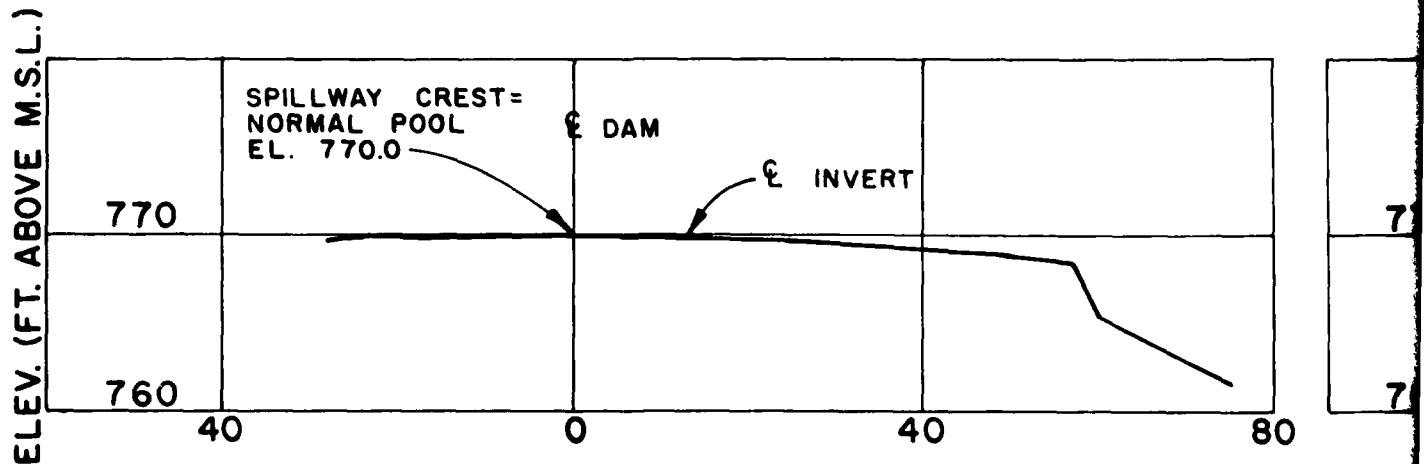
PROFILE-SPILLWAY CHANNEL
SCALES: 1"=10' V., 1"=20' H.

EL. 753.7

IV:5.2H

EL. 743.6

EL. 739.2

80   120   160   200

SECTION STA. 2+80
ES: 1"=10' V., 1"=20'H.

775.7

₵ DAM STA. 4+76

773.1

770.2

770.0
770.3
772.0

770

28' 12' 10' 4' 6' 5'

760

80 80 40 0 40
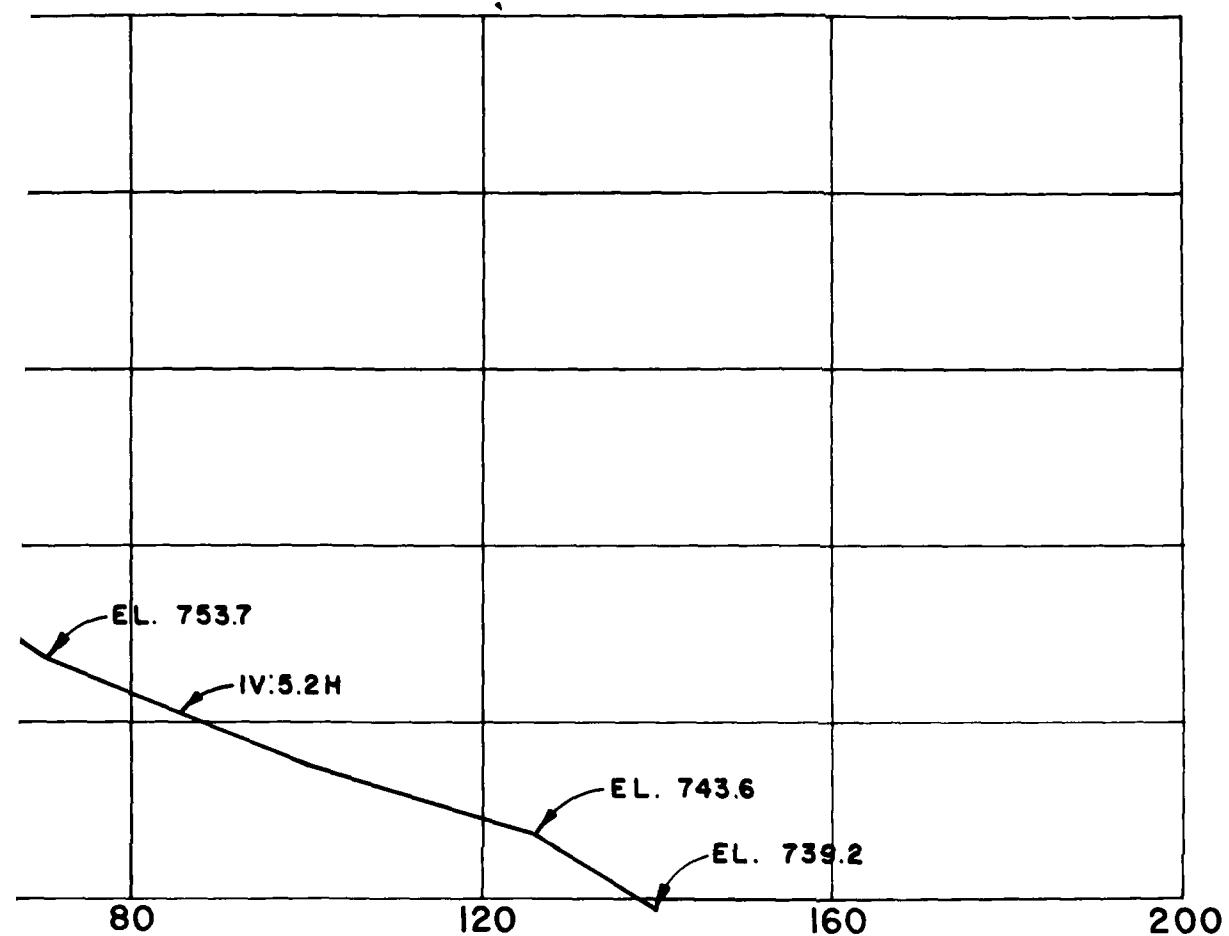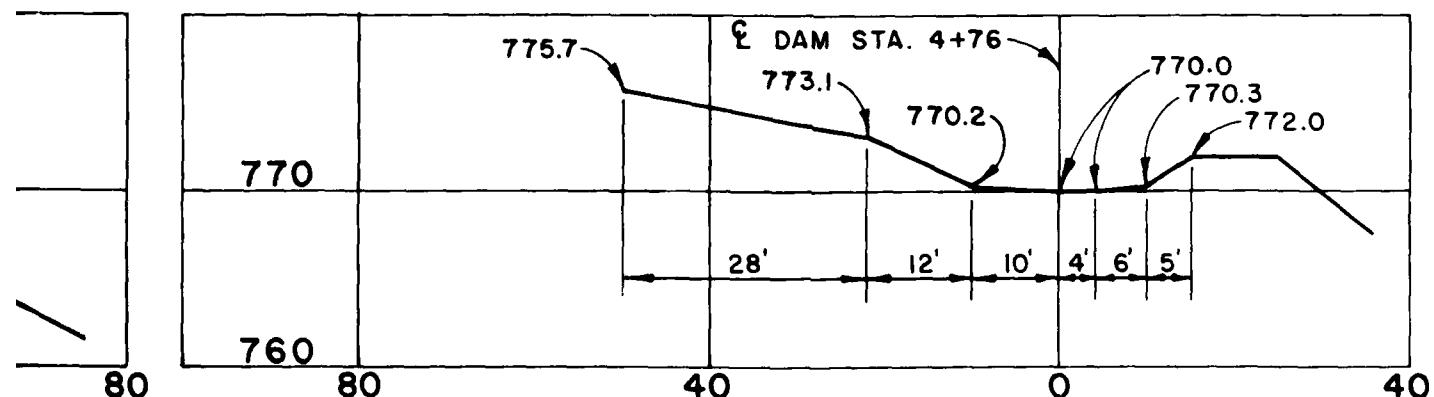
CROSS-SECTION SPILLWAY
SCALES: 1"=10' V., 1"=20'H..

WINDY KNOLL LAKE DAM
DAM CROSS-SECTION &
SPILLWAY PROFILE

Horner & Shifrin, Inc. July 1980

, 2

PLATE 4

APPENDIX A

INSPECTION PHOTOGRAPHS

NO. 1:   UPSTREAM FACE OF DAM

NO. 2:   DOWNSTREAM FACE OF DAM

NO. 3: SPILLWAY APPROACH AND CREST
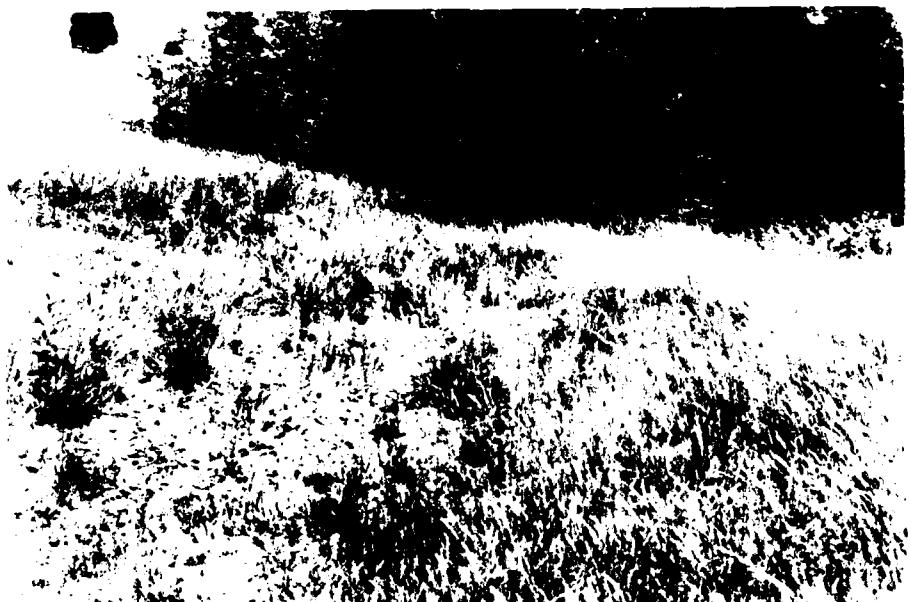
NO. 4: SPILLWAY OUTLET CHANNEL - LOOKING
DOWNSTREAM FROM CREST
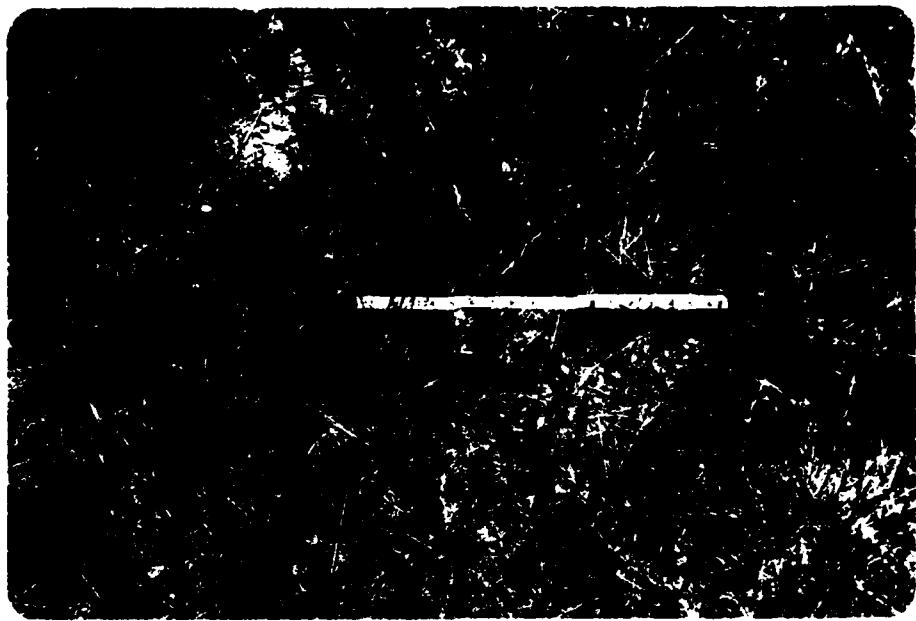
NO. 5: SURFACE CRACK IN CREST OF DAM

NO. 6: TREES (FOREGROUND) ON DOWNSTREAM FACE OF DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping anlyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.0 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year frequency) flood was provided by the St. Louis District, Corps of Engineers. Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

b. Drainage area = 0.075 square miles = 48 acres.

c. SCS parameters:

$$\text{Time of Concentration } (T_c) = (\frac{11.9L^3}{H})^{0.385} = 0.132 \text{ hours}$$

Where: T_c = Travel time of water from hydraulically most
distant point to point of interest, hours

L = Length of longest watercourse = 0.284 miles

H = Elevation difference = 52 feet

The time of concentration (Tc) was obtained using Method C as described in Figure 30, "Design of Small Dams" by the United States Department of the Interior, Bureau of Reclamation, and was veritified using average channel velocity estimates and watercourse lengths.

Lag Time = 0.079 hours (0.60 Tc)
Hydrologic Soil Group = 36% C and 64% D per SCS County Soil
Report

Soil type CN = 80 (AMC II, 100-yr flood condition)

= 91 (AMC III, PMF condition)

2. The spillway section consists of a broad-crested, trapezoidal section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (area, "a" and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth was computed as $Q_c = (\frac{a^3}{t}g)^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference, "Handbook of Hydraulics", Fifth Edition, by King and Brater, page 8-7.

c. Static lake levels corresponding to the various flow values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

3. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and the $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow over the spillway as entered on the Y4 and Y5 cards.

* $v_c = \frac{Q_c}{a}$; $H_{vc} = \frac{v^2}{2g}$

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF

HYDROLOGIC HYDRAULIC ANALYSIS OF SAFETY OF WINDY KNOLL LAKE DAM

RATIOS OF PMF ROUTED THROUGH RESERVOIR

INFLOW

INFLOW HYDROGRAPH

RESERVOIR ROUTING BY MODIFIED PULS

100-YR. FLOOD (Cont'd)

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF WINDY KNOLL LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRO	IPLT	IPRT	NSTAN
208	0	5	0	0	0	0	0	0	0

		JOPER	NWT	LROPT	TRACE
		5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRATIO= 3 LRTIO= 1

RTIOS=   .50   .55   1.00

**********   **********   **********   **********   **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAQ	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IURC	TAREA	SNAP	TRDCA	TRSFC	RATIO	IDALN	IDAME	LOCAL
1	2	.08	0.00	.70	1.00	1.00	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	102.00	120.00	130.00	0.00	0.00	1.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALOSS	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-91.00	0.00	0.00

CURVE NO = -91.00   WETNESS = -1.00   EFFECT CN = 91.00

UNIT HYDROGRAPH DATA
TC= 0.00   LAG=   .08

RECESSION DATA
STRTQ= -1.00   QRCSN=   -.10   RTIOR= 2.00

TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

UNIT HYDROGRAPH 7 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=   .08 VOL= 1.00

207.	234.	75.	24.	8.	3.	0.

```
   0                                      END-OF-PERIOD FLOW
 MO.DA  HR.MN  PERIOD  RAIN  EXCS  LOSS  COMP Q      MO.DA  HR.MN  PERIOD  RAIN  EXCS  LOSS  COMP Q
```

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.21	.01	70.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.21	.00	104.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.00	115.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.00	119.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.00	120.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.00	121.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.00	121.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.00	121.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.00	121.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.00	122.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.00	122.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.21	.00	122.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.25	.25	.00	122.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.00	142.
1.01	1.15	15	.01	.00	.01	0.	1.01	13.15	159	.26	.25	.00	145.
1.01	1.20	16	.01	.00	.01	0.	1.01	13.20	160	.26	.25	.00	146.
1.01	1.25	17	.01	.00	.01	0.	1.01	13.25	161	.25	.25	.00	146.
1.01	1.30	18	.01	.00	.01	1.	1.01	13.30	162	.25	.25	.00	147.
1.01	1.35	19	.01	.00	.01	1.	1.01	13.35	163	.26	.25	.00	147.
1.01	1.40	20	.01	.00	.01	1.	1.01	13.40	164	.25	.25	.00	147.
1.01	1.45	21	.01	.00	.01	1.	1.01	13.45	165	.26	.25	.00	147.
1.01	1.50	22	.01	.00	.01	1.	1.01	13.50	166	.26	.25	.00	147.
1.01	1.55	23	.01	.00	.01	1.	1.01	13.55	167	.26	.25	.00	147.
1.01	2.00	24	.01	.00	.01	2.	1.01	14.00	168	.26	.25	.00	147.
1.01	2.05	25	.01	.00	.01	2.	1.01	14.05	169	.32	.32	.00	162.
1.01	2.10	26	.01	.00	.01	2.	1.01	14.10	170	.32	.32	.00	177.
1.01	2.15	27	.01	.00	.01	2.	1.01	14.15	171	.32	.32	.00	182.
1.01	2.20	28	.01	.00	.01	2.	1.01	14.20	172	.32	.32	.00	183.
1.01	2.25	29	.01	.00	.01	2.	1.01	14.25	173	.32	.32	.00	184.
1.01	2.30	30	.01	.00	.01	2.	1.01	14.30	174	.32	.32	.00	184.
1.01	2.35	31	.01	.00	.01	3.	1.01	14.35	175	.32	.32	.00	184.
1.01	2.40	32	.01	.00	.01	3.	1.01	14.40	176	.32	.32	.00	184.
1.01	2.45	33	.01	.01	.01	3.	1.01	14.45	177	.32	.32	.00	184.
1.01	2.50	34	.01	.01	.01	3.	1.01	14.50	178	.32	.32	.00	184.
1.01	2.55	35	.01	.01	.01	3.	1.01	14.55	179	.32	.32	.00	175.
1.01	3.00	36	.01	.01	.01	3.	1.01	15.00	180	.32	.32	.00	184.
1.01	3.05	37	.01	.01	.01	3.	1.01	15.05	181	.15	.15	.00	185.
1.01	3.10	38	.01	.01	.01	3.	1.01	15.10	182	.39	.39	.00	171.
1.01	3.15	39	.01	.01	.01	3.	1.01	15.15	183	.39	.39	.00	197.
1.01	3.20	40	.01	.01	.01	4.	1.01	15.20	184	.58	.58	.00	264.
1.01	3.25	41	.01	.01	.01	4.	1.01	15.25	185	.68	.68	.00	306.
1.01	3.30	42	.01	.01	.01	4.	1.01	15.30	186	1.65	1.64	.00	603.
1.01	3.35	43	.01	.01	.01	4.	1.01	15.35	187	2.71	2.71	.01	1064.
1.01	3.40	44	.01	.01	.01	4.	1.01	15.40	188	1.07	1.06	.00	1029.
1.01	3.45	45	.01	.01	.01	4.	1.01	15.45	189	.68	.68	.00	658.
1.01	3.50	46	.01	.01	.01	4.	1.01	15.50	190	.58	.58	.00	455.
1.01	3.55	47	.01	.01	.01	4.	1.01	15.55	191	.39	.39	.00	330.
1.01	4.00	48	.01	.01	.01	4.	1.01	16.00	192	.39	.39	.00	258.

1.01	4.05	49	.01	.01	.01	4.	1.01	16.05	193	.30	.30	.00	213.
1.01	4.10	50	.01	.01	.01	4.	1.01	16.10	194	.30	.30	.00	185.
1.01	4.15	51	.01	.01	.01	4.	1.01	16.15	195	.30	.30	.00	176.
1.01	4.20	52	.01	.01	.01	5.	1.01	16.20	196	.30	.30	.00	174.
1.01	4.25	53	.01	.01	.01	5.	1.01	16.25	197	.30	.30	.00	173.
1.01	4.30	54	.01	.01	.01	5.	1.01	16.30	198	.30	.30	.00	173.
1.01	4.35	55	.01	.01	.01	5.	1.01	16.35	199	.30	.30	.00	172.
1.01	4.40	56	.01	.01	.01	5.	1.01	16.40	200	.30	.30	.00	172.
1.01	4.45	57	.01	.01	.01	5.	1.01	16.45	201	.30	.30	.00	172.
1.01	4.50	58	.01	.01	.01	5.	1.01	16.50	202	.30	.30	.00	172.
1.01	4.55	59	.01	.01	.01	5.	1.01	16.55	203	.30	.30	.00	172.
1.01	5.00	60	.01	.01	.01	5.	1.01	17.00	204	.30	.30	.00	172.
1.01	5.05	61	.01	.01	.01	5.	1.01	17.05	205	.23	.23	.00	157.
1.01	5.10	62	.01	.01	.01	5.	1.01	17.10	206	.23	.23	.00	143.
1.01	5.15	63	.01	.01	.00	5.	1.01	17.15	207	.23	.23	.00	138.
1.01	5.20	64	.01	.01	.00	5.	1.01	17.20	208	.23	.23	.00	136.
1.01	5.25	65	.01	.01	.00	5.	1.01	17.25	209	.23	.23	.00	136.
1.01	5.30	66	.01	.01	.00	5.	1.01	17.30	210	.23	.23	.00	136.
1.01	5.35	67	.01	.01	.00	5.	1.01	17.35	211	.23	.23	.00	136.
1.01	5.40	68	.01	.01	.00	5.	1.01	17.40	212	.23	.23	.00	136.
1.01	5.45	69	.01	.01	.00	5.	1.01	17.45	213	.23	.23	.00	136.
1.01	5.50	70	.01	.01	.00	5.	1.01	17.50	214	.23	.23	.00	136.
1.01	5.55	71	.01	.01	.00	6.	1.01	17.55	215	.23	.23	.00	136.
1.01	6.00	72	.01	.01	.00	6.	1.01	18.00	216	.23	.23	.00	136.
1.01	6.05	73	.06	.04	.02	14.	1.01	18.05	217	.02	.02	.00	105.
1.01	6.10	74	.06	.05	.02	22.	1.01	18.10	218	.02	.02	.00	95.
1.01	6.15	75	.06	.05	.02	25.	1.01	18.15	219	.02	.02	.00	90.
1.01	6.20	76	.06	.05	.02	27.	1.01	18.20	220	.02	.02	.00	85.
1.01	6.25	77	.06	.05	.01	27.	1.01	18.25	221	.02	.02	.00	80.
1.01	6.30	78	.06	.05	.01	28.	1.01	18.30	222	.02	.02	.00	75.
1.01	6.35	79	.06	.05	.01	29.	1.01	18.35	223	.02	.02	.00	70.
1.01	6.40	80	.06	.05	.01	29.	1.01	18.40	224	.02	.02	.00	65.
1.01	6.45	81	.06	.05	.01	29.	1.01	18.45	225	.02	.02	.00	61.
1.01	6.50	82	.06	.05	.01	30.	1.01	18.50	226	.02	.02	.00	57.
1.01	6.55	83	.06	.05	.01	30.	1.01	18.55	227	.02	.02	.00	53.
1.01	7.00	84	.06	.05	.01	30.	1.01	19.00	228	.02	.02	.00	49.
1.01	7.05	85	.06	.05	.01	31.	1.01	19.05	229	.02	.02	.00	46.
1.01	7.10	86	.06	.05	.01	31.	1.01	19.10	230	.02	.02	.00	43.
1.01	7.15	87	.06	.05	.01	31.	1.01	19.15	231	.02	.02	.00	40.
1.01	7.20	88	.06	.05	.01	31.	1.01	19.20	232	.02	.02	.00	37.
1.01	7.25	89	.06	.05	.01	32.	1.01	19.25	233	.02	.02	.00	35.
1.01	7.30	90	.06	.06	.01	32.	1.01	19.30	234	.02	.02	.00	33.
1.01	7.35	91	.06	.06	.01	32.	1.01	19.35	235	.02	.02	.00	30.
1.01	7.40	92	.06	.06	.01	32.	1.01	19.40	236	.02	.02	.00	28.
1.01	7.45	93	.06	.06	.01	32.	1.01	19.45	237	.02	.02	.00	26.
1.01	7.50	94	.06	.06	.01	32.	1.01	19.50	238	.02	.02	.00	25.
1.01	7.55	95	.06	.06	.01	32.	1.01	19.55	239	.02	.02	.00	23.
1.01	8.00	96	.06	.06	.01	32.	1.01	20.00	240	.02	.02	.00	21.
1.01	8.05	97	.06	.06	.01	32.	1.01	20.05	241	.02	.02	.00	20.
1.01	8.10	98	.06	.06	.01	32.	1.01	20.10	242	.02	.02	.00	17.
1.01	8.15	99	.06	.06	.01	32.	1.01	20.15	243	.02	.02	.00	17.
1.01	8.20	100	.06	.06	.01	32.	1.01	20.20	244	.02	.02	.00	16.

1.01	8.25	101	.06	.06	.00	33.	1.01	20.25	245	.02	.02	.00	15.
1.01	8.30	102	.06	.06	.00	34.	1.01	20.30	246	.02	.02	.00	14.
1.01	8.35	103	.06	.06	.00	34.	1.01	20.35	247	.02	.02	.00	13.
1.01	8.40	104	.06	.06	.00	34.	1.01	20.40	248	.02	.02	.00	12.
1.01	8.45	105	.06	.06	.00	34.	1.01	20.45	249	.02	.02	.00	12.
1.01	8.50	106	.06	.06	.00	34.	1.01	20.50	250	.02	.02	.00	12.
1.01	8.55	107	.06	.06	.00	34.	1.01	20.55	251	.02	.02	.00	12.
1.01	9.00	108	.06	.06	.00	34.	1.01	21.00	252	.02	.02	.00	12.
1.01	9.05	109	.06	.06	.00	34.	1.01	21.05	253	.02	.02	.00	12.
1.01	9.10	110	.06	.06	.00	34.	1.01	21.10	254	.02	.02	.00	12.
1.01	9.15	111	.06	.06	.00	34.	1.01	21.15	255	.02	.02	.00	12.
1.01	9.20	112	.06	.06	.00	34.	1.01	21.20	256	.02	.02	.00	12.
1.01	9.25	113	.06	.06	.00	34.	1.01	21.25	257	.02	.02	.00	12.
1.01	9.30	114	.06	.06	.00	34.	1.01	21.30	258	.02	.02	.00	12.
1.01	9.35	115	.06	.06	.00	34.	1.01	21.35	259	.02	.02	.00	12.
1.01	9.40	116	.06	.06	.00	34.	1.01	21.40	260	.02	.02	.00	12.
1.01	9.45	117	.06	.06	.00	35.	1.01	21.45	261	.02	.02	.00	12.
1.01	9.50	118	.06	.06	.00	35.	1.01	21.50	262	.02	.02	.00	12.
1.01	9.55	119	.06	.06	.00	35.	1.01	21.55	263	.02	.02	.00	12.
1.01	10.00	120	.06	.06	.00	35.	1.01	22.00	264	.02	.02	.00	12.
1.01	10.05	121	.06	.05	.00	35.	1.01	22.05	265	.02	.02	.00	12.
1.01	10.10	122	.06	.06	.00	35.	1.01	22.10	266	.02	.02	.00	12.
1.01	10.15	123	.06	.06	.00	35.	1.01	22.15	267	.02	.02	.00	12.
1.01	10.20	124	.06	.05	.00	35.	1.01	22.20	268	.02	.02	.00	12.
1.01	10.25	125	.06	.06	.00	35.	1.01	22.25	269	.02	.02	.00	12.
1.01	10.30	126	.06	.06	.00	35.	1.01	22.30	270	.02	.02	.00	12.
1.01	10.35	127	.06	.06	.00	35.	1.01	22.35	271	.02	.02	.00	12.
1.01	10.40	128	.06	.06	.00	35.	1.01	22.40	272	.02	.02	.00	12.
1.01	10.45	129	.06	.06	.00	35.	1.01	22.45	273	.02	.02	.00	12.
1.01	10.50	130	.06	.06	.00	35.	1.01	22.50	274	.02	.02	.00	12.
1.01	10.55	131	.06	.06	.00	35.	1.01	22.55	275	.02	.02	.00	12.
1.01	11.00	132	.06	.06	.00	35.	1.01	23.00	276	.02	.02	.00	12.
1.01	11.05	133	.06	.06	.00	35.	1.01	23.05	277	.02	.02	.00	12.
1.01	11.10	134	.06	.06	.00	35.	1.01	23.10	278	.02	.02	.00	12.
1.01	11.15	135	.06	.06	.00	35.	1.01	23.15	279	.02	.02	.00	12.
1.01	11.20	136	.06	.06	.00	35.	1.01	23.20	280	.02	.02	.00	12.
1.01	11.25	137	.06	.06	.00	35.	1.01	23.25	281	.02	.02	.00	12.
1.01	11.30	138	.06	.06	.00	35.	1.01	23.30	282	.02	.02	.00	12.
1.01	11.35	139	.06	.06	.00	35.	1.01	23.35	283	.02	.02	.00	12.
1.01	11.40	140	.06	.06	.00	35.	1.01	23.40	284	.02	.02	.00	12.
1.01	11.45	141	.06	.06	.00	35.	1.01	23.45	285	.02	.02	.00	12.
1.01	11.50	142	.06	.06	.00	35.	1.01	23.50	286	.02	.02	.00	12.
1.01	11.55	143	.06	.06	.00	35.	1.01	23.55	287	.02	.02	.00	12.
1.01	12.00	144	.06	.06	.00	35.	1.02	0.00	288	.02	.02	.00	12.

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                                    SUM   32.59  31.34   1.15   19085.
                                        ( 825.)( 796.)(  29.)  540.54)
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	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1024.	204.	55.	66.	19093.
CMS	31.		2.	2.	541.
INCHES		5.23	22.89	22.89	22.89
MM		432.17	635.44	635.44	635.44
AC-FT		131.	131.	131.	131.
1000 CU M		125.	162.	162.	162.

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL STAGE 770.80	SPILLWAY CREST 770.80	TOP OF DAM 772.40

RATIO OF PMF	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	772.27	0.00	228.	0.00	15.83	0.00
.55	772.43	.08	240.	.08	15.83	0.00
1.00	773.55	1.15	620.	.92	15.75	0.00

SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

	INITIAL STAGE 770.80	SPILLWAY CREST 770.80	TOP OF DAM 772.40

RATIO	MAXIMUM RESERVOIR W.S. ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM OUTFLOW	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
	771.20				15.25	0.00

DATE
ILME